

Flavor score of commercially produced whey-soy drink mix containing 41% sweet whey solids was correlated with the lactic acid content of the dehydrated material (-.75). Experimental samples prepared with a 1:1 mixture of acid whey to sweet whey and neutralized acid whey showed lower initial flavor scores than a control prepared with only sweet whey. Both samples contained over 1% total lactate reported as lactic acid compared to .4% for the control. A sample prepared with a 1:5 mixture of acid to sweet whey contained .77% lactic acid. Flavor scores of this sample after 158 days storage at 37 C, although not significantly different from the control stored under similar conditions, showed a downward trend over time. Therefore, use of small amounts of acid whey in the formulation could lead to impaired storage stability as measured by flavor acceptability during prolonged storage under adverse conditions.

INTRODUCTION

Global food shortages coupled with strict antipollution regulations have resulted in the development of new food products containing cheese whey, a previously wasted byproduct of the dairy industry. Whey-soy drink mix (WSDM), a nutritious beverage powder specifically designed as a dietary supplement for pre-school children in developing countries, contains 41% sweet whey solids in its formulation

(5). If manufactured for use in United States Title II food distribution programs in amounts projected (1), WSDM has the potential for using 22 million kg of whey solids per year.

Although comprising only 26% of all whey produced in the United States in 1975 (13), cottage cheese whey is under-utilized because of its high lactic acid content and represents an economic loss to the cheese processor. The purpose of this study was to determine if cottage cheese whey could be substituted for sweet whey in the WSDM formulation without major alteration of composition, flavor acceptability, and storage stability characteristics called for in the commodity specifications for this product (11).

MATERIALS AND METHODS

The formulation to prepare WSDM is in Table 1. Experimental samples of WSDM were prepared in the Dairy Products Laboratory pilot plant with cheddar cheese whey obtained from the Dairy Foods and Nutrition Laboratory, Beltsville, MD, and acid whey obtained from a commercial cottage cheese manufacturer in Washington, DC. In the preparation of samples of WSDM containing varying amounts of lactic acid, 1:5 and 1:1 mixtures of acid to sweet whey were used as the source of whey solids. A sample was also prepared with acid whey which had been neutralized to pH 5.95 with sodium hydroxide. Neutralization was necessary prior to sample formulation to prevent the powder from sticking in the cone and star valve of the spray dryer. A sample prepared with only sweet whey served as a control.

Nutrisoy 220⁴ full fat soy flour containing 42.7% protein, 20.2% fat, and 4.4% moisture was used in preparation of all samples. Frodex 42 D.E. corn syrup solids and Crisco brand soybean oil completed the formulation.

A 20-kg lot of each sample was prepared by wet blending the soy flour, soybean oil, and corn syrup solids into pasteurized fluid whey which had been preheated to 38 to 43 C. The mixture was homogenized in two stages at pres-

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³ Agricultural Research Service, U.S. Department of Agriculture.

⁴ Reference to brand or firm name does not constitute endorsement by the U.S. Department of Agriculture over others of a similar nature not mentioned.

TABLE 1. Formulation of WSDM.

Ingredient	Per- cent
Sweet whey solids	41.7
Full fat soy flour	36.9
Soybean oil	12.3
Corn syrup solids	9.1

tures of 175.8 kg/cm² and 38.7 kg/cm². It then was pasteurized in a Mallory tubular heater for 15 s at 77 C, condensed to 40% total solids in a Harris-Wiegand falling film evaporator, and spray dried in a 2.7 m Grey-Jensen spray dryer equipped with a .075 cm nozzle and an inlet temperature of 146 C.

The procedure for the determination of ash in the sample was that recommended by the AOAC (2). Total lactate was measured by the colorimetric procedure of Lawrence (7) and titratable acidity by a method developed by the Agricultural Marketing Service (12). Results from both measurements were reported as percent lactic acid.

For storage stability studies, samples of the experimental powder made only with sweet whey were packed under nitrogen in No. 211 × 414 cans and stored at -18 C to serve as a control. Additional samples of all four of the experimental powders were air packed in No. 211 × 414 cans and stored at 37 C.

For organoleptic evaluation, all taste panels were trained dairy products judges selected for sensory acuity (8) who had received additional training in recognition of beany, rancid, and reverted soybean oil flavors. Panels averaged 13 judges with a minimum of 10 judges on one panel. Samples of WSDM were withdrawn from storage after 18, 46, 102, and 158 days. The samples were reconstituted with distilled water to 15% total solids just prior to being tasted. The reconstituted control sample that had been stored at -18 C was divided into two parts. One part was presented to the judges as a known control that had been given a score of 7 based on a 10 point score sheet developed by sensory evaluation specialists at the Northern Regional Research Center (3). The other part was presented to the judges as a hidden control along with samples stored at the elevated temperature. The score received by the hidden con-

TABLE 2. Effect of water-soluble components of WSDM on pH.

Ingredient	pH
Fluid sweet whey	6.20
Fluid sweet whey + corn syrup solids	6.20
Fluid sweet whey + corn syrup solids + full fat soy flour	6.22

trol served as the standard against which the scores received by the other samples were compared. Statistical evaluations for significance were made after completion of each taste panel by analysis of variance and Duncan's Multiple Range Test according to Larmond (6).

Peroxide values were determined on all stored samples as another measure of oxidative stability. Fat for peroxide analysis was extracted from the powders without heat by blending 1 g dry sample with 2 g Celite 545. The dry mixtures were placed in glass columns, 30 cm × 1 cm ID (inner diameter), equipped with coarse sintered glass discs, and the peroxide-containing fat was eluted into a 25 ml volumetric flask with benzene:methanol (70:30). After appropriate dilution of the samples with the same solvent mixture, peroxide values were determined directly by the colorimetric procedure of Hills and Thiele as described by Stine et al. (10).

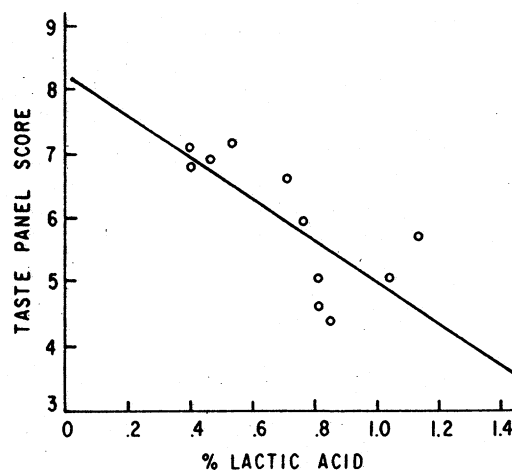


FIG. 1. Relationship of average flavor score to lactic acid content of commercial WSDM samples.

TABLE 3. Acid characteristics of fluid wheys used for production of experimental WSDM.

	Sweet whey	Acid whey	1:5 A:S	1:1 A:S	Neutralized acid whey
Titrateable acidity (%)	.10	.40	.14	.24	.13
Lactic acid (%)	.10	.59	.17	.34	.58
pH	6.37	4.80	5.89	5.29	6.06

Samples of WSDM manufactured under USDA contracts for distribution abroad were obtained from their manufacturers or from the Agricultural Marketing Service Dairy Division, Chicago, IL. These samples were reconstituted, tasted as described above, and analyzed for lactate content.

RESULTS

Commodity specifications call for a minimum pH of 5.9 in finished WSDM (11). Cottage cheese whey has a pH of about 4.7 and contains an average of 9.6% lactic acid on a total solids basis; fresh sweet whey has a pH of 6.0 to 6.5 and a lactic acid content of 1% or less (4). Although the lactic acid content of cottage cheese whey or the development of lactic acid in the sweet whey used to manufacture WSDM could be expected to be an important factor influencing pH, other components in the formulation also might affect the pH of the reconstituted beverage. The effect of the individual water soluble ingredients used in the WSDM formulation is shown in Table 2. Corn syrup solids added in their correct proportion to fresh fluid sweet whey did not change the pH because of the buffering capacity of the whey salts; the addition of soy flour slightly raised the pH toward neutrality.

Lactic acid also imparts a distinctive sour off-flavor to whey. To determine if the lactic acid had any influence on flavor score of WSDM, a series of commercially prepared WSDM samples were analyzed for lactic acid content and subjected to organoleptic evaluation by trained judges. Least squares analysis showed that the data represented a straight line described by the equation $y = -3.25x + 8.22$, where y = the average flavor score and x = the percent lactic acid in the powder (Fig. 1). The correlation coefficient was -0.75 , indicating that about 56% of the variation in flavor score was due to variation in lactic acid content. As percentage of lactic acid increased, there was an overall decrease in flavor score.

Although these results seem to preclude the use of cottage cheese whey in the WSDM formulation, no information was available about the treatment, age, or acidity of the sweet whey used to manufacture the commercial samples. Therefore, the acid characteristics of mixtures of sweet and acid wheys and neutralized acid whey were compared to those of sweet whey (Table 3). The 1:5 mixture of acid to sweet whey yielded a titrateable acidity of .14%, a value typical for sweet whey (14). Neutralized acid whey had a titrateable acidity of .13%, but measurement of the true lactate content of .58% was equivalent to .59% mea-

TABLE 4. Acid characteristics of WSDM prepared with acid whey.

	Control (sweet whey)	1:5 A:S	1:1 A:S	Neutralized acid whey
Titrateable acidity (%)	.51	.80	.99	.72
Lactic acid (%)	.40	.77	1.36	3.39
pH (15% total solids)	6.45	6.15	5.85	6.05

TABLE 5. Average flavor scores of WSDM containing different percents of acid whey and stored at 37 C.

Sample	Initial	Flavor score storage time, days			
		18	46	102	158
Hidden control (-18 C, N ₂ pack)	6.80	6.30	6.35	6.66	6.42
Stored 37 C					
Control	...	6.57	6.70	6.45	6.28
1:5, A:S	7.20	6.34	6.30	6.25	5.82
1:1, A:S	5.77*	4.88*	5.15*	4.75*	4.28*
Neutralized acid whey	5.49*	4.61*	4.35*	3.50*	3.21*

*Different from the hidden control at 1%.

sured in the untreated acid whey.

The titratable acidity, lactic acid, and pH of the finished powders prepared with these wheys are in Table 4. The figures for titratable acidity and pH for WSDM prepared with neutralized acid whey suggested that this product should be acceptable, but the true lactate content of 3.39% indicated that some flavor problems might be anticipated. Both pH and lactate content of the sample prepared with a 1:1 mixture of acid to sweet whey indicated that the reconstituted drink might be unacceptable to consumers whereas both the control and the sample containing a 1:5 mixture of acid to sweet whey would be acceptable.

Flavor scores were obtained for all the products (Table 5). Initial flavor scores for the products containing a 1:1 mixture of acid to sweet whey or containing neutralized acid whey were lower ($P<.01$) than both the control and the sample containing a 1:5 mixture of acid to sweet whey. After 18 days of storage at 37 C, the flavors of the two samples receiving signifi-

cantly lower scores initially had deteriorated even further. Scores of the control stored at 37 C changed only slightly over the 158-day storage. However, scores of the samples containing a 1:5 mixture of acid to sweet whey, even though rated as acceptable as the hidden control at any one tasting, showed slightly more flavor deterioration over the same period of storage.

Determination of peroxide values for all samples tasted showed that the off-flavor was not due to oxidation of the edible oil component of WSDM (Table 6). Although the peroxide values of all samples steadily increased over the period of storage, the measured increases were still below those associated with the identification of oxidized and rancid flavors by taste panels in earlier studies (9).

Commodity specifications permit a maximum ash content of 6.5% in WSDM fortified with 1% vitamins and minerals. The ash contents of the unfortified WSDM containing different amounts of acid whey are in Table 7. As

TABLE 6. Peroxide values (meq O₂/kg fat) of WSDM containing different percents of acid whey and stored at 37 C.

Sample	Initial	Peroxide value storage time, days			
		18	46	102	158
Hidden control (-18 C, N ₂ pack)	9.8	7.7	9.5	8.5	10.6
Stored 37 C					
Control	...	10.9	18.1	28.0	43.1
1:5, A:S	9.5	8.9	17.6	25.2	34.7
1:1, A:S	9.2	10.9	16.8	23.7	33.3
Neutralized acid whey	8.8	10.0	14.8	18.8	26.9

TABLE 7. Ash content of WSDM containing different percents of acid whey.

Sample	Ash content %
Control	5.34
1:5, A:S	5.56
1:1, A:S	5.82
Neutralized acid whey	6.86

mineral fortification raises the ash content by nearly 1%, all of the samples containing acid whey would approach to or exceed the maximum ash content permitted, even though the sample containing the 1:5 mixture of acid to sweet whey had acceptable flavor and storage stability.

DISCUSSION

Whey-soy drink mix has been procured from commercial sources and distributed abroad for almost 3 yr. In that time, there has been only one complaint from overseas about severe off-flavor in the product. The questionable sample contained 1.20% lactic acid, approaching the 1.36% lactic acid in the experimental sample containing a 1:1 mixture of acid to sweet whey. The lactic acid could be contributed only by the whey in the formulation.

All other commercial samples that were evaluated met the commodity specifications for minimum pH. However, our results showed that increased content of lactic acid was correlated with decreased flavor acceptability in these samples, even though they were acceptable abroad. In addition, the results suggest that if WSDM is manufactured with only small amounts of cottage cheese whey, storage stability as measured by flavor acceptability might be impaired after extended storage under adverse conditions even in a powder containing as little as .77% lactic acid.

The findings show that formulation of WSDM with acid whey or neutralized acid whey will not meet commodity specifications. For good flavor quality and storage stability, WSDM should be prepared from fresh fluid sweet whey of pH 5.9 or higher with a titratable acidity of .15% or less and a true lactate content of .17% or less. If the sweet whey used as an ingredient is handled in a manner con-

sistent with good dairy plant management, manufacturers of WSDM should have no difficulty in achieving a finished product containing less than .8% lactic acid. Such a product will maintain good flavor for an extended time even when subjected to the storage conditions in many developing countries where WSDM is sent as part of the United States Food for Peace Program.

REFERENCES

- 1 Anon. 1974. The beverage made to order. *Farm Index* 13(3):19.
- 2 Association of Official Analytical Chemists. 1970. Page 247 in *Official Methods of Analysis*, 11th ed., Washington, DC.
- 3 Bookwalter, G. N., H. A. Moses, V. F. Pfeifer, and E. L. Griffin. 1968. Storage stability of blended food products, formula No. 2: a corn-soy-milk food supplement. *Food Technol.* 22:1581.
- 4 Holsinger, V. H. 1976. New dairy products for use in candy manufacture. *Manufacturing Confectioner* 56(1):25.
- 5 Holsinger, V. H., C. S. Sutton, L. F. Edmondson, P. R. Crowley, B. L. Berntson, and M. J. Pallansch. 1974. 4th International Congress of Food Science and Technology, Madrid, Spain, September 23-27. Session 8a, New Food Sources of Key Nutrients, No. 7, p. 16. (Abstr.)
- 6 Larmond, E. 1970. Methods for sensory evaluation of food. Publication 1284, Canada Department of Agriculture, Ottawa, Canada.
- 7 Lawrence, A. J. 1970. A rapid method of estimation of lactic acid in skim milk powder. *Aust. J. Dairy Technol.* 25:198.
- 8 Liming, N. E. 1966. Consistency of a trained taste panel. *J. Dairy Sci.* 49:628.
- 9 Pallansch, M. J. 1975. Progress in development of whey-soy drink. Page 48 in *Proceedings of the Whey Products Conference*, Chicago, Illinois, September 18-19, 1974. USDA, ERRC Publ. No. 3996.
- 10 Stine, C. M., H. A. Harland, S. T. Coulter, and R. Jenness. 1954. A modified peroxide test for detection of lipid oxidation in dairy products. *J. Dairy Sci.* 37:202.
- 11 USDA, Agricultural Stabilization and Conservation Service. 1975. Purchase of whey soy drink mix for use in export programs. Announcement WD-3, July 25, Shawnee Mission, KS.
- 12 USDA, Consumer and Marketing Service. 1971. Page 7 in *Methods of laboratory analysis for dry whey*. DA Instruction No. 918-108-2, February 1. Washington, DC.
- 13 USDA, Statistical Reporting Service, Crop Reporting Board. 1976. *Dairy Products Annual Summary 1975*. DA 2-1(76). U.S. Government Printing Office, Washington, DC.
- 14 Wong, N. P. 1974. In *Fundamentals of Dairy Chemistry*, 2nd ed. B. H. Webb, A. H. Johnson, and J. A. Alford, ed. Avi Publishing Company, Inc., Westport, CT. p. 727.